AD-A044 516 ARMY ELECTRONICS COMMAND FORT MONMOUTH N J F/G 18/8

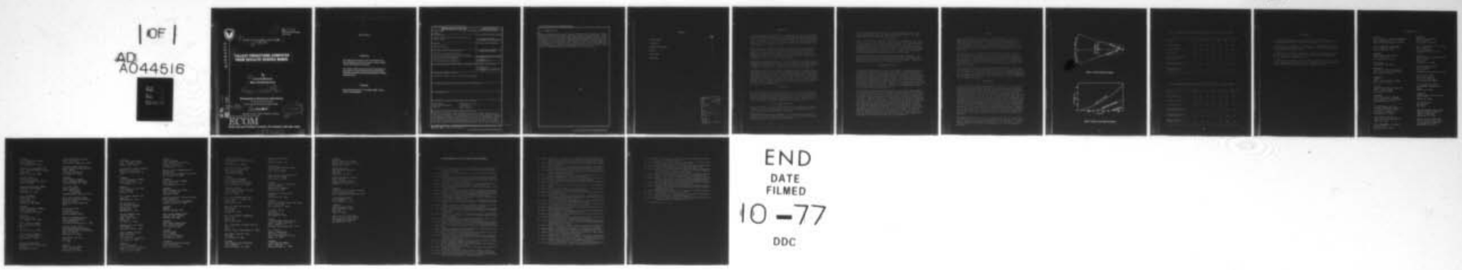
FALLOUT PREDICTIONS COMPUTED FROM SATELLITE DERIVED WINDS.(U)

JUN 77 L D DUNCAN, M A SEAGRAVES

UNCLASSIFIED ECOM-5823 NL

| OF |

AD
A044516



END
DATE
FILMED
10-77
DDC

AD

Reports Control Symbol
OSD-1366

12

RESEARCH AND DEVELOPMENT TECHNICAL REPORT ,

ECOM - 5823

AD A 044516

FALLOUT PREDICTIONS COMPUTED FROM SATELLITE DERIVED WINDS .

By

Louis D./Duncan

Mary Ann/Seagraves

1L162111AH71 A2

Atmospheric Sciences Laboratory

US Army Electronics Command

White Sands Missile Range, New Mexico 88002

13p.

June 1977

Approved for public release; distribution unlimited.

ECOM

UNITED STATES ARMY ELECTRONICS COMMAND - FORT MONMOUTH, NEW JERSEY 07703

037620 LB

NOTICES

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The citation of trade names and names of manufacturers in this report is not to be construed as official Government indorsement or approval of commercial products or services referenced herein.

Disposition

Destroy this report when it is no longer needed. Do not return it to the originator.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ECOM-5823
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): FALLOUT PREDICTIONS COMPUTED FROM SATELLITE DERIVED WINDS
5. TYPE OF REPORT & PERIOD COVERED: R&D Technical Report
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): Louis D. Duncan, Mary Ann Seagraves
8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Atmospheric Sciences Laboratory, White Sands Missile Range, New Mexico 88002
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: DA Task No. 1L162111AH71A267
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Electronics Command, Fort Monmouth, New Jersey 07703
12. REPORT DATE: June 1977
13. NUMBER OF PAGES: 15
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):
15. SECURITY CLASS. (of this report): UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:
16. DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited.
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):
18. SUPPLEMENTARY NOTES:
19. KEY WORDS (Continue on reverse side if necessary and identify by block number):

Meteorology	Temperature retrieval
Satellite meteorology	Transmission
Radiation	Remote sensing

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The utility of thermal winds computed from satellite thermal sounder observations is investigated. The investigation is in terms of the downrange distance and radial lines used for construction of nuclear fallout predictions. Empirical estimates of the accuracies of these quantities are obtained by comparisons with the same quantities determined from radiosonde data. Sixty sets of colocated satellite and radiosonde observations were used in these evaluations.

For each comparison, corresponding fallout predictions were computed for a

Next Page

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (cont)

range of assumed nuclear yields between 100 kilotons and 5 megatons. Thermal winds derived from the satellite data were used at the upper altitude. Tie-on altitudes of 15 and 10 km were used. RMS differences between the predictands derived from the two methods of determining winds yielded values of less than 5 degrees for the radial lines and less than 3 percent for the downrange distance when the 15 km tie-on was used. When the 10 km values were used for tie-on, RMS values for radial line differences varied from 3 to 9.5 degrees, while those for downrange distance varied between 0 and 7.5 percent.

CONTENTS

INTRODUCTION

The steadily improving capabilities in meteorological satellites, together with innovative techniques for satellite data analysis and interpretation, have provided many new tools and techniques for observing the earth and its atmosphere. This report discusses a specific application of satellite data - the prediction of hazardous areas which could result from the detonation of a nuclear device.*

During the past 3 decades, considerable research has been expended towards solving the technically complex problems associated with fallout prediction. Approximate techniques which can be used under tactical battlefield conditions have resulted from these research efforts. The current procedures for fallout prediction under tactical conditions are described in FM 3-22, "Fallout Prediction" [1].

The primary meteorological inputs to fallout prediction are the wind data obtained by balloonsonde soundings (usually referred to as radiosondes) of the upper atmosphere made by the US Army Artillery Meteorological Sections. Soundings to at least 30 km altitude are required at 6-hour intervals.

Techniques for inferring the upper altitude wind data from spectral radiance data obtained by satellite borne thermal sounders have been developed and evaluated [2,3]. In brief, these techniques employ the thermal wind equations to complete the upper portions of the wind profile. Radiosonde observations are used for the lower levels and serve as a tie-on for the thermal winds. A tie-on altitude in the neighborhood of 10-15 km altitude is used. In this report the emphasis is placed upon the user product - the actual fallout prediction.

DISCUSSION

The fallout prediction, as described in FM 3-22, results in the development of a diagram such as the one shown in Fig. 1. To perform the prediction, one must know the wind profiles from the earth's surface to the top of the nuclear cloud and the yield from the blast. The wind profile is used to obtain an effective wind profile which is defined by

$$\vec{V}_e(Z) = \int_0^Z f(\zeta)\,\vec{W}(\zeta)\,d\zeta$$

where $\vec{W}(\zeta)$ and $\vec{V}_e(Z)$ are the actual and effective wind profiles, respectively, the $f(\zeta)$ is the weighting function which is obtained from the fall rate of the radioactive debris particles.

*Currently operational Army techniques for fallout prediction were employed in this study. Meteorological satellite data were used to obtain atmospheric inputs required for the predictions.

The principal predictands required for the construction of Fig. 1 are the downrange distance and the right and left radial lines. The downrange distance, R, is obtained from the formula

$$R = AY^{2/5} V^{1/2}$$

where Y is the nuclear yield, V is the effective windspeed at the bottom of the cloud, and A is a proportionality constant. The radial lines are obtained from the direction of the effective wind at the top of the nuclear cloud and at the two-thirds stem height. If these two directions are separated by at least 40 degrees, they are taken as the radial lines; otherwise, the average of these directions is computed and the radial lines are determined by adding and subtracting 20 degrees.

For a specified yield the fallout prediction becomes a function of the effective windspeed at the cloud bottom height and the effective wind directions at the cloud top height and the 2/3 stem height. These three heights are shown in Fig. 2 as a function of yield.

COMPARATIVF ANALYSIS

Theoretical estimation of the absolute accuracies of the fallout prediction computed from satellite derived winds appears virtually untenable at this time because of dependency upon several sources of errors. The more practical approach is through statistical comparison with predictions computed from other wind measurement systems. The radiosonde system was selected as a standard for comparison because this is the current method for obtaining upper altitude wind data for most applications and data from this system is readily obtainable. However, it is important to point out that rather large errors are often inherent in such measurements, especially during high wind conditions [4].

A special data collection was begun at White Sands Missile Range (WSMR), NM, in February 1975 to obtain a sample of radiosonde data for comparison with NOAA 4 and 5 satellite data. Radiosonde balloons were released approximately 1 hour before the satellite passover in order to minimize errors due to temporal variability. (Approximately 100 minutes is required for balloon rise to 30 km altitude.) Data extending through February 1977 were used for this study, which resulted in a sample size of 60 cases. The following pressure layers were selected for computation of thermal winds from the satellite sounder data: 10-20, 20-40, 40-80, 80-150, and 150-300 mbs. Corresponding altitudes for the boundaries of these layers are approximately 31, 26.5, 22, 17.4, 13.8, and 9.4 km. In 28 of the samples, radiosonde data were not available for the 10-20 mb layer because the balloon burst before the top of the layer; eight samples were unavailable for the 20-40 mb layer for the same reason.

RESULTS

Fallout predictions were computed for the 60 comparative samples discussed in the previous section and for yields of 100, 250, 500, 750, 1000, 2500, and 5000 kilotons. Yields less than 100 kilotons were not considered because the results for the 100 kiloton case indicates very good comparisons, and it is rather evident that computations for smaller yields would result in even smaller differences between the two sets of comparisons.

Two separate sets of comparisons were performed. The first case used 15 km as the tie-on altitudes for the satellite data while 10 km was used as tie-on in the second case. The root mean square (rms) was used as the measure of the difference between the predictions obtained from the comparisons. Results are shown in Table 1 and 2.* For completeness, the altitudes for the cloud top, the cloud bottom, and two-thirds stem height are included.

The downrange distance, R, varies considerably from case to case because of the variation in effective windspeed. For this reason it was decided that rms values of percent differences would be a more meaningful measure for the comparison. Since this value will be zero for yields having cloud bottom heights below the tie-on altitude, the tables include listings only for the appropriate yields.

CONCLUSIONS

The results shown in Table 1 demonstrate the capability of the satellite derived winds to provide reliable fallout predictions even for nuclear yields in the megaton range. The rms values are for differences between the predictands computed from radiosonde alone and predictands using radiosonde data below 15 km with satellite derived thermal winds used to complete the profile. As such, it must be remembered that these rms values represent errors from two sources - the errors in the radiosonde wind measurements and the errors in the winds derived from the satellite data. Although these errors cannot be separated at this time, it is well known that the radiosonde measurements can contain significant errors and this leads to the obvious conclusion that the prediction errors attributed to the satellite data are surely less than the rms values shown. As expected, the rms values shown in Table 2 for the 10 km tie-on are larger than those shown in Table 1. Still these values are relatively small and indicate that the satellite data with this tie-on can provide usable predictions.

---

*It should be noted that for 2/3 stem heights less than the tie-on altitude, the direction of the effective wind will be the same for both techniques. However, because of the adjustment of 40° separation, a nonzero rms difference for the radial corresponding to the 2/3 stem height is possible.

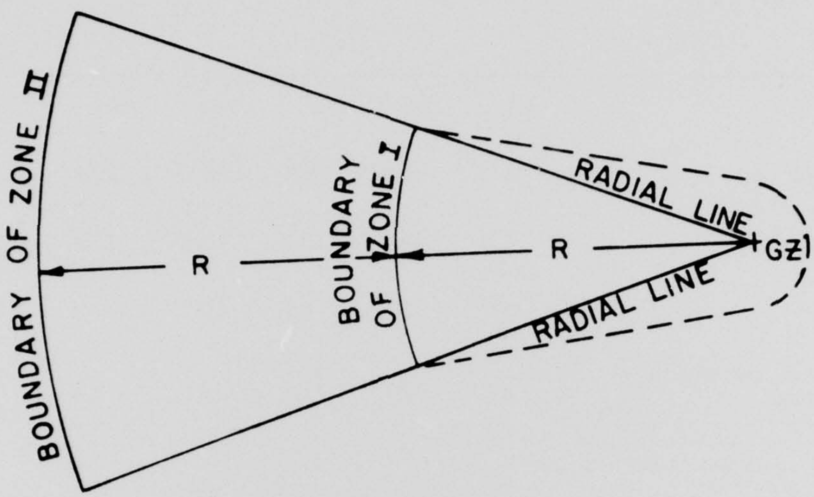


Figure 1. Fallout prediction diagram.

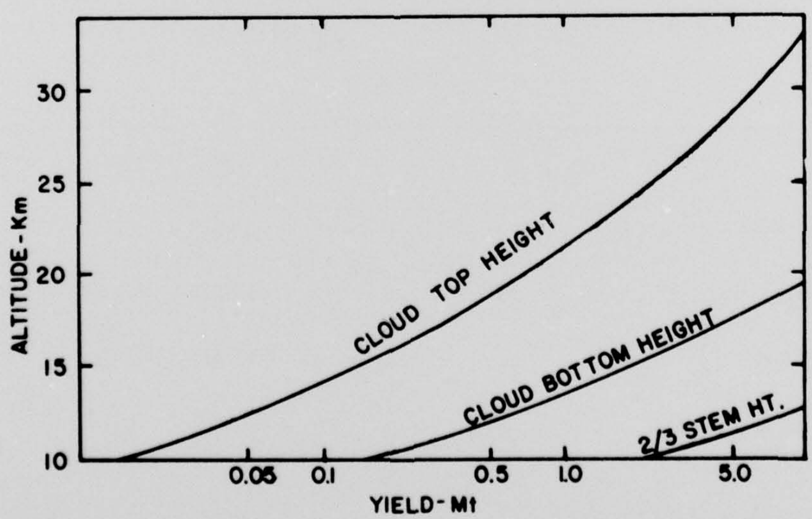


Figure 2. Nuclear cloud height parameters.

TABLE 1. COMPARISON OF PREDICTIONS FROM RADIOSONDE TO SATELLITE DATA, 15 KM TIE-ON ALTITUDE

Yield (kt)	100	250	500	750	1000	2500	5000
Cloud Top Height (km)	14.3	16.4	19.1	20.7	21.8	25.5	28.9
Cloud Bottom Height (km)	9.3	10.7	12.1	12.8	13.4	15.4	17.3
2/3 Stem Height	6.2	7.2	8.1	8.6	8.9	10.3	11.5
RMS Difference in Radial Line to Cloud Top (deg)	0	1.0	2.8	3.4	4.5	4.3	5.6
RMS Difference in Radial Line to 2/3 Stem Height (deg)	0	0.7	1.7	2.1	2.4	4.2	4.8
RMS Percent Difference in Downrange Distance	0	0	0	0	0	0.5	2.8

TABLE 2. COMPARISON OF PREDICTIONS FROM RADIOSONDE AND SATELLITE DATA, 10 KM TIE-ON ALTITUDE

Yield (kt)	100	250	500	750	1000	2500	5000
Cloud Top Height (km)	14.3	16.4	19.1	20.7	21.8	25.5	28.9
Cloud Bottom Height (km)	9.3	10.7	12.1	12.8	13.4	15.4	17.3
2/3 Stem Height (km)	6.2	7.2	8.1	8.6	8.9	10.3	11.5
RMS Difference in Radial Line to Cloud Top (deg)	3.3	4.3	5.6	6.6	7.1	8.6	9.5
RMS Difference in Radial Line to Cloud Bottom (deg)	2.9	3.9	5.0	5.7	6.5	8.3	9.4
RMS Percent Difference in Downrange Distance, R	0	2.6	5.7	6.2	6.4	6.8	7.5

REFERENCES

1. Department of the Army Field Manual FM 3-22, "Fallout Predictions," Headquarters, Department of the Army, Washington, D. C., Oct 73.

2. Duncan, L. D., "SATFAL - The Application of Meteorological Satellite Data to Nuclear Fallout Predictions" presented at the 1976 Army Science Conference, West Point, NY, Jun 76.

3. Duncan, L. D., and M. A. Seagraves, "Evaluation of the NOAA-4 VTPR Thermal Winds for Nuclear Fallout Predictions," US Army Atmospheric Sciences Laboratory, WSMR, NM, Mar 77.

4. Miller, W. B., and D. R. Veazey, "Vertical Efficiency of Active and Passive Balloon Tracking Systems from a Standpoint of Integrated Errors," US Army Atmospheric Sciences Laboratory, WSMR, NM, Aug 73.

DISTRIBUTION LIST

Director
US Army Ballistic Research Laboratory
ATTN: DRDAR-BLB, Dr. G. E. Keller
Aberdeen Proving Ground, MD 21005

Air Force Weapons Laboratory
ATTN: Technical Library (SUL)
Kirtland AFB, NM 87117

Commander
Headquarters, Fort Huachuca
ATTN: Tech Ref Div
Fort Huachuca, AZ 85613

6585 TG/WE
Holloman AFB, NM 88330

Commandant
US Army Field Artillery School
ATTN: Morris Swett Tech Library
Fort Sill, OK 73503

Commandant
USAFAS
ATTN: ATSF-CD-MT (Mr. Farmer)
Fort Sill, OK 73503

Director
US Army Engr Waterways Exper Sta
ATTN: Library Branch
Vicksburg, MS 39180

Commander
US Army Electronics Command
ATTN: DRSEL-CT-S (Dr. Swingle)
Fort Monmouth, NJ 07703
03

CPT Hugh Albers, Exec Sec
Interdept Committee on Atmos Sci
Fed Council for Sci & Tech
National Sci Foundation
Washington, DC 20550

Inge Dirmhirn, Professor
Utah State University, UMC 48
Logan, UT 84322

HQDA (DAEN-RDM/Dr. De Percin)
Forrestal Bldg
Washington, DC 20314

Commander
US Army Aviation Center
ATTN: ATZQ-D-MA
Fort Rucker, AL 36362

CO, USA Foreign Sci & Tech Center
ATTN: DRXST-ISI
220 7th Street, NE
Charlottesville, VA 22901

Director
USAE Waterways Experiment Station
ATTN: Library
PO Box 631
Vicksburg, MS 39180

US Army Research Office
ATTN: DRXRO-IP
PO Box 12211
Research Triangle Park, NC 27709

Mr. William A. Main
USDA Forest Service
1407 S. Harrison Road
East Lansing, MI 48823

Library-R-51-Tech Reports
Environmental Research Labs
NOAA
Boulder, CO 80302

Commander
US Army Dugway Proving Ground
ATTN: MT-S
Dugway, UT 84022

HQ, ESD/DRI/S-22
Hanscom AFB
MA 01731

Head, Atmospheric Rsch Section
National Science Foundation
1800 G. Street, NW
Washington, DC 20550

Office, Asst Sec Army (R&D)
ATTN: Dep for Science & Tech
HQ, Department of the Army
Washington, DC 20310

Commander
US Army Satellite Comm Agc
ATTN: DRCPM-SC-3
Fort Monmouth, NJ 07703

Sylvania Elec Sys Western Div
ATTN: Technical Reports Library
PO Box 205
Mountain View, CA 94040

William Peterson
Research Association
Utah State University, UNC 48
Logan, UT 84322

Defense Communications Agency
Technical Library Center
Code 205
Washington, DC 20305

Dr. A. D. Belmont
Research Division
PO Box 1249
Control Data Corp
Minneapolis, MN 55440

Commander
US Army Electronics Command
ATTN: DRSEL-WL-D1
Fort Monmouth, NJ 07703

Commander
ATTN: DRSEL-VL-D
Fort Monmouth, NJ 07703

Meteorologist in Charge
Kwajalein Missile Range
PO Box 67
APO
San Francisco, CA 96555

The Library of Congress
ATTN: Exchange & Gift Div
Washington, DC 20540
2

US Army Liaison Office
MIT-Lincoln Lab, Library A-082
PO Box 73
Lexington, MA 02173

Dir National Security Agency
ATTN: TDL (C513)
Fort George G. Meade, MD 20755

Director, Systems R&D Service
Federal Aviation Administration
ATTN: ARD-54
2100 Second Street, SW
Washington, DC 20590

Commander
US Army Missile Command
ATTN: DRSMI-RRA, Bldg 7770
Redstone Arsenal, AL 35809

Dir of Dev & Engr
Defense Systems Div
ATTN: SAREA-DE-DDR
H. Tannenbaum
Edgewood Arsenal, APG, MD 21010

Naval Surface Weapons Center
Technical Library & Information
Services Division
White Oak, Silver Spring, MD
20910

Dr. Frank D. Eaton
PO Box 3038
Universtiy Station
Laramie, Wyoming 82071

Rome Air Development Center
ATTN: Documents Library
TILD (Bette Smith)
Griffiss Air Force Base, NY 13441

National Weather Service
National Meteorological Center
World Weather Bldg - 5200 Auth Rd
ATTN: Mr. Quiroz
Washington, DC 20233

USAFETAC/CB (Stop 825)
Scott AFB
IL 62225

Director
Defense Nuclear Agency
ATTN: Tech Library
Washington, DC 20305

Director
Development Center MCDEC
ATTN: Firepower Division
Quantico, VA 22134

Environmental Protection Agency
Meteorology Laboratory
Research Triangle Park, NC
27711

Commander
US Army Electronics Command
ATTN: DRSEL-GG-TD
Fort Monmouth, NJ 07703

Commander
US Army Ballistic Rsch Labs
ATTN: DRXBR-IB
APG, MD 21005

Dir, US Naval Research Lab
Code 5530
Washington, DC 20375

Mil Assistant for
Environmental Sciences
DAD (E & LS), 3D129
The Pentagon
Washington, DC 20301

The Environmental Rsch
Institute of MI
ATTN: IRIA Library
PO Box 618
Ann Arbor, MI 48107

Armament Dev & Test Center
ADTC (DLOSL)
Eglin AFB, Florida 32542

Range Commanders Council
ATTN: Mr. Hixon
PMTC Code 3252
Pacific Missile Test Center
Point Mugu, CA 93042

Commander
Eustis Directorate
US Army Air Mobility R&D Lab
ATTN: Technical Library
Fort Eustis, VA 23604

Commander
Frankford Arsenal
ATTN: SARFA-FCD-O, Bldg 201-2
Bridge & Tarcony Sts
Philadelphia, PA 19137

Director, Naval Oceanography and
Meteorology
National Space Technology Laboratories
Bay St Louis, MS 39529

Commander
US Army Electronics Command
ATTN: DRSEL-CT-S
Fort Monmouth, NJ 07703

Commander
USA Cold Regions Test Center
ATTN: STECR-OP-PM
APO Seattle 98733

Redstone Scientific Information Center
ATTN: DRDMI-TBD
US Army Missile Res & Dev Command
Redstone Arsenal, AL 35809

Commander
AFWL/WE
Kirtland AFB, NM 87117

Naval Surface Weapons Center
Code DT-22 (Ms. Greeley)
Dahlgren, VA 22448

Commander
Naval Ocean Systems Center
ATTN: Research Library
San Diego, CA 92152

Commander
US Army INSCOM
ATTN: IARDA-OS
Arlington Hall Station
Arlington, VA 22212

Commandant
US Army Field Artillery School
ATTN: ATSF-CF-R
Fort Sill, OK 73503

Commander and Director
US Army Engineer Topographic Labs
ETL-GS-AC
Fort Belvoir, VA 22060

Technical Processes Br-D823
NOAA, Lib & Info Serv Div
6009 Executive Blvd
Rockville, MD 20852

Commander
US Army Missile Research
and Development Command
ATTN: DRDMI-CGA, B. W. Fowler
Redstone Arsenal, AL 35809

Commanding Officer
US Army Armament Rsch & Dev Com
ATTN: DRDAR-TSS #59
Dover, NJ 07801

Air Force Cambridge Rsch Labs
ATTN: LCB (A. S. Carten, Jr.)
Hanscom AFB
Bedford, MA 01731

National Center for Atmos Res
NCAR Library
PO Box 3000
Boulder, CO 80307

Air Force Geophysics Laboratory
ATTN: LYD
Hanscom AFB
Bedford, MA 01731

Chief, Atmospheric Sciences Division
Code ES-81
NASA
Marshall Space Flight Center, AL 35812

Department of the Air Force
OL-C, 5WW
Fort Monroe, VA 23651

Commander
US Army Missile Rsch & Dev Com
ATTN: DRDMI-TR
Redstone Arsenal, AL 35809

Meteorology Laboratory
AFGL/LY
Hanscom AFB, MA 01731

Director CFD
US Army Field Artillery School
ATTN: Met Division
Fort Sill, OK 73503

Naval Weapons Center (Code 3173)
ATTN: Dr. A. Shlanta
China Lake, CA 93555

Director
Atmospheric Physics & Chem Lab
Code R31, NOAA
Department of Commerce
Boulder, CO 80302

Department of the Air Force
5 WW/DN
Langley AFB, VA 23665

Commander
US Army Intelligence Center and School
ATTN: ATSI-CD-MD
Fort Huachuca, AZ 85613

Dr. John L. Walsh
Code 4109
Navy Research Lab
Washington, DC 20375

Director
US Army Armament Rsch & Dev Com
Chemical Systems Laboratory
ATTN: DRDAR-CLJ-I
Aberdeen Proving Ground, MD 21010

R. B. Girardo
Bureau of Reclamation
E&R Center, Code 1220
Denver Federal Center, Bldg 67
Denver, CO 80225

Commander
US Army Missile Command
ATTN: DRDMI-TEM
Redstone Arsenal, AL 35809

Commander
US Army Tropic Test Center
ATTN: STETC-MO (Tech Library)
APO New York 09827

Commanding Officer
Naval Research Laboratory
Code 2627
Washington, DC 20375

Defense Documentation Center
ATTN: DDC-TCA
Cameron Station (Bldg 5)
Alexandria, Virginia 22314
12

Commander
US Army Test and Evaluation Command
ATTN: Technical Library
White Sands Missile Range, NM 88002

US Army Nuclear Agency
ATTN: MONA-WE
Fort Belvoir, VA 22060

Commander
US Army Proving Ground
ATTN: Technical Library
Bldg 2100
Yuma, AZ 85364

Office, Asst Sec Army (R&D)
ATTN: Dep for Science & Tech
HQ, Department of the Army
Washington, DC 20310

ATMOSPHERIC SCIENCES RESEARCH PAPERS

1. Lindberg, J.D., "An Improvement to a Method for Measuring the Absorption Coefficient of Atmospheric Dust and other Strongly Absorbing Powders," ECOM-5565, July 1975.
2. Avara, Elton, P., "Mesoscale Wind Shears Derived from Thermal Winds," ECOM-5566, July 1975.
3. Gomez, Richard B., and Joseph H. Pierluissi, "Incomplete Gamma Function Approximation for King's Strong-Line Transmittance Model," ECOM-5567, July 1975.
4. Blanco, A.J., and B.F. Engebos, "Ballistic Wind Weighting Functions for Tank Projectiles," ECOM-5568, August 1975.
5. Taylor, Fredrick J., Jack Smith, and Thomas H. Pries, "Crosswind Measurements through Pattern Recognition Techniques," ECOM-5569, July 1975.
6. Walters, D.L., "Crosswind Weighting Functions for Direct-Fire Projectiles," ECOM-5570, August 1975.
7. Duncan, Louis D., "An Improved Algorithm for the Iterated Minimal Information Solution for Remote Sounding of Temperature," ECOM-5571, August 1975.
8. Robbiani, Raymond L., "Tactical Field Demonstration of Mobile Weather Radar Set AN/TPS-41 at Fort Rucker, Alabama," ECOM-5572, August 1975.
9. Miers, B., G. Blackman, D. Langer, and N. Lorimier, "Analysis of SMS/GOES Film Data," ECOM-5573, September 1975.
10. Manquero, Carlos, Louis Duncan, and Rufus Bruce, "An Indication from Satellite Measurements of Atmospheric CO2 Variability," ECOM-5574, September 1975.
11. Petracca, Carmine, and James D. Lindberg, "Installation and Operation of an Atmospheric Particulate Collector," ECOM-5575, September 1975.
12. Avara, Elton P., and George Alexander, "Empirical Investigation of Three Iterative Methods for Inverting the Radiative Transfer Equation," ECOM-5576, October 1975.
13. Alexander, George D., "A Digital Data Acquisition Interface for the SMS Direct Readout Ground Station — Concept and Preliminary Design," ECOM-5577, October 1975.
14. Cantor, Israel, "Enhancement of Point Source Thermal Radiation Under Clouds in a Nonattenuating Medium," ECOM-5578, October 1975.
15. Norton, Colburn, and Glenn Hoidale, "The Diurnal Variation of Mixing Height by Month over White Sands Missile Range, N.M," ECOM-5579, November 1975.
16. Avara, Elton P., "On the Spectrum Analysis of Binary Data," ECOM-5580, November 1975.
17. Taylor, Fredrick J., Thomas H. Pries, and Chao-Huan Huang, "Optimal Wind Velocity Estimation," ECOM-5581, December 1975.
18. Avara, Elton P., "Some Effects of Autocorrelated and Cross-Correlated Noise on the Analysis of Variance," ECOM-5582, December 1975.
19. Gillespie, Patti S., R.L. Armstrong, and Kenneth O. White, "The Spectral Characteristics and Atmospheric CO2 Absorption of the Ho^{+3}:YLF Laser at 2.05μm," ECOM-5583, December 1975.
20. Novlan, David J. "An Empirical Method of Forecasting Thunderstorms for the White Sands Missile Range," ECOM-5584, February 1976.
21. Avara, Elton P., "Randomization Effects in Hypothesis Testing with Autocorrelated Noise," ECOM-5585, February 1976.
22. Watkins, Wendell R., "Improvements in Long Path Absorption Cell Measurement," ECOM-5586, March 1976.
23. Thomas, Joe, George D. Alexander, and Marvin Dubbin, "SATTEL — An Army Dedicated Meteorological Telemetry System," ECOM-5587, March 1976.
24. Kennedy, Bruce W., and Delbert Bynum, "Army User Test Program for the RDT&E-XM-75 Meteorological Rocket," ECOM-5588, April 1976.

25. Barnett, Kenneth M., "A Description of the Artillery Meteorological Comparisons at White Sands Missle Range, October 1974 - December 1974 ('PASS' - Prototype Artillery [Meteorological] Subsystem)," ECOM-5589, April 1976.
26. Miller, Walter B., "Preliminary Analysis of Fall-of-Shot From Project 'PASS'," ECOM-5590, April 1976.
27. Avara, Elton P., "Error Analysis of Minimum Information and Smith's Direct Methods for Inverting the Radiative Transfer Equation," ECOM-5591, April 1976.
28. Yee, Young P., James D. Horn, and George Alexander, "Synoptic Thermal Wind Calculations from Radiosonde Observations Over the Southwestern United States," ECOM-5592, May 1976.
29. Duncan, Louis D., and Mary Ann Seagraves, "Applications of Empirical Corrections to NOAA-4 VTPR Observations," ECOM-5593, May 1976.
30. Miers, Bruce T., and Steve Weaver, "Applications of Meterological Satellite Data to Weather Sensitive Army Operations,"ECOM-5594, May 1976.
31. Sharenow, Moses, "Redesign and Improvement of Balloon ML-566," ECOM-5595, June, 1976.
32. Hansen, Frank V., "The Depth of the Surface Boundary Layer," ECOM-5596, June 1976.
33. Pinnick, R.G., and E.B. Stenmark, "Response Calculations for a Commercial Light-Scattering Aerosol Counter," ECOM-5597, July 1976.
34. Mason, J., and G.B. Hoidale, "Visibility as an Estimator of Infrared Transmittance," ECOM-5598, July 1976.
35. Bruce, Rufus E., Louis D. Duncan, and Joseph H. Pierluissi, "Experimental Study of the Relationship Between Radiosonde Temperatures and Radiometric-Area Temperatures," ECOM-5599, August 1976.
36. Duncan, Louis D., "Stratospheric Wind Shear Computed from Satellite Thermal Sounder Measurements," ECOM-5800, September 1976.
37. Taylor, F., P. Mohan, P. Joseph and T. Pries, "An All Digital Automated Wind Measurement System," ECOM-5801, September 1976.
38. Bruce, Charles, "Development of Spectrophones for CW and Pulsed Radiation Sources," ECOM-5802, September 1976.
39. Duncan, Louis D., and Mary Ann Seagraves,"Another Method for Estimating Clear Column Radiances," ECOM-5803, October 1976.
40. Blanco, Abel J., and Larry E. Taylor, "Artillery Meteorological Analysis of Project Pass," ECOM-5804, October 1976.
41. Miller, Walter, and Bernard Engebos," A Mathematical Structure for Refinement of Sound Ranging Estimates," ECOM-5805, November, 1976.
42. Gillespie, James B., and James D. Lindberg, "A Method to Obtain Diffuse Reflectance Measurements from 1.0 to 3.0 μm Using a Cary 17I Spectrophotometer," ECOM-5806, November 1976.
43. Rubio, Roberto, and Robert O. Olsen,"A Study of the Effects of Temperature Variations on Radio Wave Absorption,"ECOM-5807, November 1976.
44. Ballard, Harold N., "Temperature Measurements in the Stratosphere from Balloon-Borne Instrument Platforms, 1968-1975," ECOM-5808, December 1976.
45. Monahan, H.H., "An Approach to the Short-Range Prediction of Early Morning Radiation Fog," ECOM-5809, January 1977.
46. Engebos, Bernard Francis, "Introduction to Multiple State Multiple Action Decision Theory and Its Relation to Mixing Structures," ECOM-5810, January 1977.
47. Low, Richard D.H.,"Effects of Cloud Particles on Remote Sensing from Space in the 10-Micrometer Infrared Region," ECOM-5811, January 1977.
48 Bonner, Robert S., and R. Newton, "Application of the AN/GVS-5 Laser Rangefinder to Cloud Base Height Measurements," ECOM-5812, February 1977.

49. Rubio, Roberto, "Lidar Detection of Subvisible Reentry Vehicle Erosive Atmospheric Material," ECOM-5813, March 1977.
50. Low, Richard D.H., and J.D. Horn, "Mesoscale Determination of Cloud-Top Height: Problems and Solutions," ECOM-5814, March 1977.
51. Duncan, Louis D., and Mary Ann Seagraves, "Evaluation of the NOAA-4 VTPR Thermal Winds for Nuclear Fallout Predictions," ECOM-5815, March 1977.
52. Randhawa, Jagir S., M. Izquierdo, Carlos McDonald and Zvi Salpeter, "Stratospheric Ozone Density as Measured by a Chemiluminescent Sensor During the Stratcom VI-A Flight," ECOM-5816, April 1977.
53. Rubio, Roberto, and Mike Izquierdo, "Measurements of Net Atmospheric Irradiance in the 0.7- to 2.8-Micrometer Infrared Region," ECOM-5817, May 1977.
54. Ballard, Harold N., Jose M. Serna, and Frank P. Hudson Consultant for Chemical Kinetics, "Calculation of Selected Atmospheric Composition Parameters for the Mid-Latitude, September Stratosphere," ECOM-5818, May 1977.
55. Mitchell, J.D., R.S. Sagar, and R.O. Olsen, "Positive Ions in the Middle Atmosphere During Sunrise Conditions," ECOM-5819, May 1977.
56. White, Kenneth O., Wendell R. Watkins, Stuart A. Schleusener, and Ronald L. Johnson, "Solid-State Laser Wavelength Identification Using a Reference Absorber," ECOM-5820, June 1977.
57. Watkins, Wendell R., and Richard G. Dixon, "Automation of Long-Path Absorption Cell Measurements," ECOM-5821, June 1977.
58. Taylor, S.E., J.M. Davis, and J.B. Mason, "Analysis of Observed Soil Skin Moisture Effects on Reflectance," ECOM-5822, June 1977.
59. Duncan, Louis D. and Mary Ann Seagraves, "Fallout Predictions Computed from Satellite Derived Winds," ECOM-5823, June 1977.

☆U.S. GOVERNMENT PRINTING OFFICE: 1977 777-022/6